

Sealing Cracks in Asphalt Concrete Pavements

by *J-F. Masson*

This Update gives insights into the preventive maintenance of asphalt concrete pavements. The aim is to extend the life of these pavements through sealing practices that achieve results with better than usual performance.

Cracking of asphalt concrete (AC) pavements is a recurring problem. If left unchecked, it can lead to serious degradation of the infrastructure and to a short life span of the pavement. Cracks allow the infiltration of water, brine and debris into the sub-structure of the pavement, causing further degradation and eventually failure.

One of the most common techniques of preventive maintenance for AC pavements is to seal the cracks. But this treatment has not been meeting its full potential. Sealants often fail within three years mainly because of inappropriate sealant selection and application.¹ A sealant should provide at least 5 years of service life without debonding.

Sealant Selection

In warmer climates, such as southern British Columbia or southern Ontario and the central U.S. states, sealants can provide good durability. However, sealants used in the repair of roads subjected to arctic and sub-arctic climates must be able to endure unusual stresses. The low temperatures occurring during a typical winter in Canada and the northern U.S. can make sealants inelastic so they no longer adapt to the temperature-induced increase in crack width. The sealants then debond, no longer tightly contacting the crack walls (Figure 1).

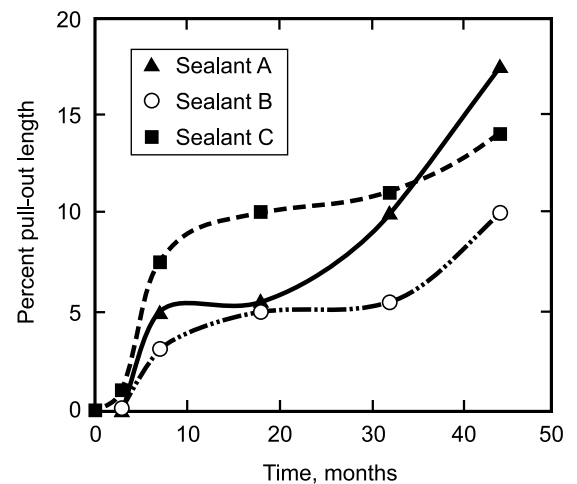


Figure 1. Typical failure profiles for three sealants

Hot-poured, bituminous sealants used for crack sealing are generally selected according to empirical and prescriptive standards such as ASTM D3405.² But the standards specify the best sealant for average climate conditions, not necessarily the best for cold climates.¹ Sealants that achieve the standard requirements show good performance for only two to four years in cold climates. No standards are available for the selection of high-performance sealants required for extended service life up to ten years. For cold climates, sealants with penetrations between 90 and 130 dmm (9 to 13 mm) at 25°C and viscosities lower than 15 Pa.s (15000 cP) at 185°C appear to perform best.^{1,3}

Sealing in Cold Climates

The crack-sealing procedure now used in cold climates has evolved over the last twenty years. In the past, cracks were simply cleared of debris with pressurized air and then filled with sealant.⁴ Nowadays cracks undergo much more preparation aimed at increasing sealant durability.

First a router is used to modify the profile (the cross-sectional dimensions) of the crack so that it is at least as wide as it is deep. The router must follow wandering cracks without tearing, chipping or spalling the edges so that, in a single pass, the profile of the crack changes to square or rectangular. (As a matter of terminology: once a crack has been routed, it is referred to as a rout.) For good performance, the rout must have a width-to-depth ratio equal to or greater than one. In an urban setting, to reduce contact with the tires of passing vehicles, the width of the rout should not be more than about 30 mm. Sealed routs measuring 30 mm wide by 15 mm deep or 25 by 12 mm generally perform well. On highways, routs are most often 40 mm by 10 mm.

After routing is complete, pressurized hot air is used to dry and heat the rout. A hot-air lance (HAL) is widely used in Canada and the northern U.S. to prepare routs for sealing. The temperature of the HAL should be below 500°C so moisture can be effectively removed without overheating the routs. Overheating of the routs reduces sealant bonding.⁵

Finally, the crack sealant is heated in a melter until it becomes fluid. Once melted, the sealant can be poured into the crack. The melter, or kettle, consists of two concentric compartments. Hot oil circulates in the outer compartment. Inside is the sealant reservoir where an agitator helps distribute the heat within the sealant. High temperatures increase the rate of sealant degradation;⁶ therefore the molten sealant should be held at a temperature below 180°C and only for the shortest possible time. Even at recommended

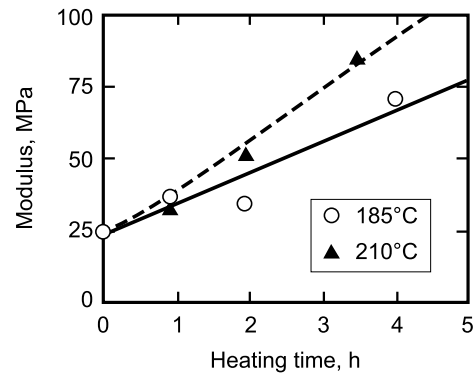


Figure 2. Heating causes an increase in sealant stiffness (modulus) that may lead to early failure.

application temperatures, long heating times lead to sealant degradation (Figure 2). Using a melter with a relatively small reservoir or keeping a large reservoir only half-filled can prevent long heating times.

When to Seal

The best time to rout and seal is during late summer to mid fall, when cooler pavement temperatures cause the pavement cracks to open up somewhere between their maximum and minimum apertures (Figure 3). By sealing cracks when the pavement temperature is average, less stress is put on the sealant bond and bonding failures are much less likely. It should be noted that similar temperatures can also occur during the spring, but this is the time that frost is coming out of the ground and pavement moisture is normally at its maximum. However, if pavement moisture does not appear to be a problem, then such work could be done

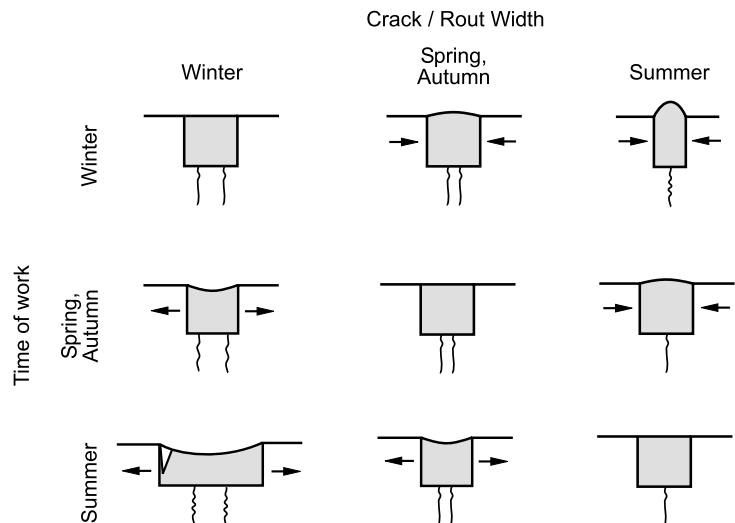


Figure 3. Effect of crack opening and time of work on sealant strain. A sealant may fail prematurely in winter, if work is done in summer (bottom left). A protruding sealant becomes prone to damage in summer, if sealing is done in winter (upper right). Arrows show the direction of crack movement.

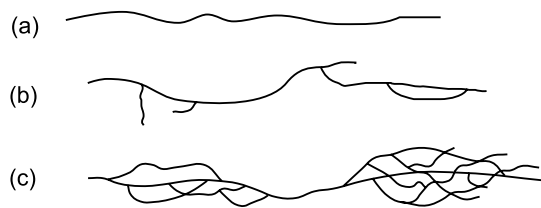


Figure 4. For successful sealing, cracks should show little or no branching. Cracks illustrated in (a) and (b) are suitable for sealing, but the crack in (c) shows excessive branching.

in the later spring after the frost has completely come out of the ground and the subgrade has dried up.

A Step-by-Step Approach

1. Determine the Suitability of the AC Pavement for Crack Sealing.

Check for suitability of crack sealing by determining whether the cracks

- are less than 15 or 20 mm wide;
- are not part of a web of cracks;
- show little or no branching (Figure 4); and
- show no severe vertical distress, such as lipping or cupping.⁴

Large cracks lead to permanent damage of the road structure and provide for inefficient rout and seal. When it is necessary to treat cracks larger than 15-20 mm, do not rout, but simply clean and seal with an overband.

Actions Aimed at Safe Operations

- Control traffic by using delineators, flashers, barricades, traffic signs and possibly a flag person.
- Ensure that workers are protected from flying debris and from equipment hazards.
- Consult data sheets regarding safe use of hot sealant materials.

2. Rout Cracks to Create a Sealant Reservoir.

Ensure the profile of the rout is square or rectangular. Rounded bottoms and V-shaped routs create conditions for sealant debonding. Do not rout cracks in AC pavements known to be oxidized and brittle, as severe spalling may result.

- Use a metal die in the shape of the rout profile. Check its width and depth by running the die along one metre of the crack.

Select a rout width at least 10 mm wider than the crack width, the maximum rout width being 30 and 40 mm on city streets and highways, respectively.

3. Clean the Pavement Surface and Heat the Rout.

Cleaning is a critical step in crack treatment. Many problems attributed to adhesion failure result from dirty or moist cracks. The surface of the road must also be cleaned of debris from the routing operation. (In urban settings, dust and debris from the routing operation must be retrieved.)

- Remove as much debris as possible from the surface of the pavement so that dust is not blown back into the rout just before it is sealed. For this first cleaning step, a large mechanical sweeper or vacuum system can be used.
- Remove any remaining debris and loose fragments from the rout. This job is best done with high-pressure air, free of oil and moisture. It also removes some moisture in the rout. (Check the high-pressure air for oil or moisture contamination by blowing cold air onto the side of a tire. Clean air leaves no deposits.)
- When air temperatures dip between 5 and 10°C, use the HAL to warm the rout surface and to remove some humidity. Keep the HAL temperature below 500°C. (The temperature range of the HAL is indicated by the colour at its hot end. If it is bright orange to bright red, the temperature is 600 to 1100°C; if dark red, 500 to 600°C; if black, 400 to 500°C.)

4. Check for Cleanliness.

Use duct tape to check the cleanliness of the crack. Press about one metre of the sticky surface of the tape into the rout and pull it out. After proper cleaning, there should be very little, if any, residue on the tape.

5. Prepare and Pour Hot-applied Sealant.

- Reduce sealant degradation by heating the sealants to the lowest temperature recommended by the material supplier. For instance, if the recommended application temperature is 175 to 195°C, heat to 175°C. Heat to the upper limiting temperature only when sealant viscosity is greater than 15 Pa.s at 185°C.
- Heat only enough sealant to complete the work at hand. Do not reheat the sealant.

- Avoid continued heating of sealant overnight at low heat. The advantage of rapid start-up in the morning is not worth the sealant degradation that will have occurred, and the rapid sealant failure that may follow.

6. Pour and Shape Sealant.

- Pour the sealant into the rout in a continuous motion.
- Either flush-fill or bridge the routs with sealant.

Bridging 5 mm on either side of the rout is considered optimal. This configuration prevents pooling of water on the sealant, which may recess after cooling. The bridge should be 1 to 2 mm thick. Flush-filled routs are preferred where the risk of sealant pullout by snowplowing is great.

7. Protect Sealant from Traffic Damage.

After the sealant has been poured, it is best to protect it from traffic for 30 to 45 minutes. Apply a covering of Portland cement or fine sand to prevent sealant adhesion to tires. Biodegradable absorbing paper placed on top of the sealed rout also provides protection.

Summary

Crack sealing, if done properly, can be an effective preventive measure for maintaining AC pavements. A sealant should provide a minimum service life of five years with no debonding. Following the guidelines presented here for proper routing, cleaning, and sealant preparation and application will go a long way toward ensuring good performance.

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June 2001
ISSN 1206-1220